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DATA EVALUATION RECORD

STUDY 8

CHEM 036101

Trifluralin

§163-2

FORMULATION--12--EMULSIFIABLE CONCENTRATE (EC)

STUDY ID 40673601C

Nash R.G. 1983. Comparative volatilization and dissipation rates of several pesticides from soil. J. Agric. Food Chem. 31:210-217.

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CONCLUSIONS:

Mobility - Laboratory Volatility

This laboratory volatility study provides supplemental data. It cannot be used to fulfill the data requirement (163-2). These data were taken from published articles and were not originally designed to satisfy Subdivision N data requirements. Therefore, it is difficult to draw the conclusions needed for an environmental fate assessment. However, these data and other published volatility data submitted (MRID 40673601A, 40673601B, 40673601D, 40673601E, 40673601F, 40673601G) do indicate the following:

1. Volatility may be a major route of dissipation for trifluralin.
2. Trifluralin appears to volatilize (\approx 25 to 60% of applied in 11 days).
3. Data are needed to determine relative rate of dissipation due to volatility in relation to other routes of dissipation.

In this study the material balance was incomplete (only 66.8% of applied trifluralin was accounted for after 11 days). In addition, trifluralin was applied as a component of a mixture of pesticides with the initial concentration of trifluralin on soil being low (72% of application rate). Furthermore, the soil concentration data were too variable to confirm the application rate; and the study was terminated before the pattern of decline of the test substance was established.

METHODOLOGY:

Laboratory volatility

Trifluralin (EC, concentration not specified) was sprayed at 2.8 kg/ha (in 1978) and at 2.0 kg/ha (in 1979) in combination with other pesticides onto the surface of a sandy loam soil (79% sand, 7% silt, 14% clay, 0.6% organic matter, pH 6.8, 6% moisture at 0.33 kPa) contained in glass chambers (150 cm long, 50 cm wide, 100 cm high above 15 cm of soil) in a greenhouse. Air was pumped into the system at a rate of 0.08 m/s and vented through twelve outlets, each of which was covered with a polyurethane filter. In 1978, trifluralin was mixed with lindane, heptachlor, chlordane, dieldrin, endrin, and DDT and the mixture was sprayed onto the soil surface; the trifluralin application rate was 2.8 kg/ha (Table I). In 1979, two experiments were conducted, trifluralin (EC, concentration not specified) was mixed in two treatment solutions. The first solution contained trifluralin, lindane, heptachlor, and esters of 2,4-D; the second solution contained trifluralin, lindane, heptachlor, dieldrin, esters of 2,4-D, and esters of 2,4,5-T. These mixtures were sprayed separately onto the soil surfaces; the trifluralin application rate was 2 kg/ha (Table I). Plastic film was placed around the sides of the container during spraying to prevent chamber side wall contamination. The volatile trapping system was the same as that used the previous year. Air filters and soil samples (15.1 cm in depth by 2 cm in diameter) were sampled periodically for 11 days in 1978 and for 3 days in 1979. All samples were stored at -5 C until assayed.

Air filters from 1978 were Soxhlet extracted for 2 hours with petroleum ether; the extract was concentrated by rotary evaporation and analyzed by GLC with electron capture detection. Air filters from 1979 were Soxhlet extracted for 5 hours with hexane:methanol:water (100:35:15, v:v:v). The extract was shaken with saturated sodium chloride solution; the organic portion was dried over sodium sulfate, the aqueous portion was extracted with hexane and the second hexane extract was also dried over sodium sulfate. The combined hexane extracts were analyzed by GLC as described above. Soil samples (both 1978 and 1979) were extracted and analyzed as previously described for the 1979 air filters, except that florisisil was added to the extracting solution. Trapping efficiencies of the air filters for trifluralin were determined to be 80% (Table I).

DATA SUMMARY:

In 1978, trifluralin (EC) applied at 2.8 kg/ha in a mixture with lindane, heptachlor, chlordane, dieldrin, endrin, and DDT, volatilized from sandy loam soil. At 11 days posttreatment, 126 mg or 60.3% of the applied trifluralin was extracted from the air filters (Table IV). Trifluralin remaining on the soil surface was 6.5% of the applied. At the end of the experiment in 1978, the material balance for trifluralin was 66.8% of the applied.

In 1979, trifluralin (EC) applied at 2.0 kg/ha in a mixture with lindane, heptachlor, and esters of 2,4-D; or lindane, heptachlor, dieldrin, esters of 2,4-D, and esters of 2,4,5-T, did not appear to significantly volatilize from the surface of sandy loam soil. Trifluralin concentrations were 79-80% at 0-0.63 days after application, 64% at 0.81 days, and ranged from 52-61% on 0.98-2.2 days, with no discernible pattern (Table VI). Since air concentration data were not provided for the 1979 portion of the experiment, material balances could not be calculated.

COMMENTS:

1. In 1978, after 11 days of volatilization, the material balance was incomplete; only 66.8% of the applied trifluralin was accounted for after correcting for the filter-trapping efficiency (80%). No data for air concentration of trifluralin were included for 1979; therefore, material balances could not be determined for samples in 1979.
2. The study was terminated before the pattern of decline of trifluralin was established. Samples were taken for 11 days in 1978, and for 3 days in 1979.
3. In this study, trifluralin was applied with several other pesticides. The presence of other pesticide may have had an effect on the volatilization of trifluralin in this system. The study author did not address this point.
4. The method of calculating application rate was unclear. In 1978, only 72% of applied trifluralin remained on the soil at 0.065 days (1.56 hours) after application, but at 1.41 days (33.84 hours), 98% of the applied trifluralin remained (Table III); the data were similar for 1979 (Table VI). The study author stated that there were three or four replications of each soil sampling but data were not presented in a manner that permitted independent assessment of the variation.
5. All samples were stored at -5 C until assayed; acceptable storage stability data for trifluralin were submitted to the EPA (Study 1, Decker, D.O., MRID 41661101, reviewed by Dynamac and submitted to the EPA on May 2, 1991). In this ancillary freezer storage stability study, trifluralin was stable in acetonitrile:soil slurries stored at 4 C for up to 454 days.

6. The adsorption K value was not given for the sandy loam soil used in these experiments.
7. The study author cited a vapor pressure of 32.2 mPa at 30 C obtained from Spencer and Cliath 1973, J. Environ. Qual. 2:264 (Table II).
8. This study is one of several published papers included as appendices to MRID 40673601 (Day, E.W. 1988. Laboratory and field volatility studies with trifluralin from soil. Laboratory Project ID. EWD8807). This document was submitted as an assessment of the potential inhalation hazard of trifluralin to exposed workers. Because this portion of the document contains summary data only and is not pertinent to Subdivision N guidelines, it was not reviewed; only the published papers in the appendices have been reviewed.
9. EFGWB prefers that [¹⁴C]residues in samples be separated by chromatographic methods (such as TLC, HPLC, and GC) solvent systems of different polarity, and that specific compounds isolated by chromatography be identified using a confirmatory method such as MS in addition to comparison to the R_f of reference standards.

In this study aliquots of the extracts were analyzed by GLC.

STUDY AUTHOR(S)'S RESULTS AND/OR CONCLUSIONS
(INCLUDING PERTINENT TABLES AND FIGURES)

Table I. Common and Chemical Names of Pesticides, Their Application Rates to Surface Soil in Chambers, and Air-Filter Trapping Efficiencies

common	chemical	treatment rate, kg ha ⁻¹		air-filter efficiency, %
		1978	1979	
trans-chlordane	1,3-exo,4-endo,7,9,9,10,10-octachloro-2,3,6,5-endo-tricyclo[5.2.1.0 ^{4,6}]dec-8-ene	1		98
cis-chlordane	1,3-exo,4-exo,7,8,9,10,10-octachloro-2,3,6,5-endo-tricyclo[5.2.1.0 ^{4,6}]dec-8-ene	1.2		94
p,p'-DDD	1,1-dichloro-2,2-bis(p-chlorophenyl)ethane	0.57		79
p,p'-DDT	1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane	1.7		97
dieldrin	1,3,9,10,11,11-hexachloro-4,5-exo-epoxy-2,3,7,6-endo,2,1,7,8-exo-tetracyclo[6.2.1.1 ^{3,4} .0 ^{4,5}]dodec-9-ene	2	2	96
endrin	1,5,9,10,11,11-hexachloro-4,5-exo-epoxy-2,1,7,8-endo,2,3,7,6-endo-tetracyclo[6.2.1.1 ^{3,4} .0 ^{4,5}]dodec-9-ene	2		79
heptachlor	1,3-exo,7,8,9,10,10-heptachloro-2,3,6,5-endo-tricyclo[5.2.1.0 ^{4,6}]deca-4,8-diene	4.5	2	94
heptachlor epoxide	1,3-exo,7,8,9,10,10-heptachloro-4,5-exo-epoxy-2,3,6,5-endo-tricyclo[5.2.1.0 ^{4,6}]dec-8-ene	0.08		105
lindane	γ isomer of 1,2,3,4,5,6-hexachlorocyclohexane	0.97	2	86
trifluralin	o,o,o-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine	2.8	2	80
2,4-D	isooctyl ester of (2,4-dichlorophenoxy)acetic acid		2.6	62*
2,4-D	propylene glycol butyl ether ester of 2,4-D		2	87*
2,4,5-T	isooctyl ester of (2,4,5-trichlorophenoxy)acetic acid		2	105*
2,4,5-T	propylene glycol butyl ether ester of 2,4,5-T		2	88*

* As ester.

RESULTS AND DISCUSSION

Air-Filter Sampling. Pesticide concentrations in air filters that were sampled at 1 or 2 h and taken from the lower three, middle six, or upper three chamber sections were compared to ascertain the effect of time and position on pesticide trapping efficiencies and quantities. A paired t test for daily pesticide means and 59 degrees of freedom (df) indicated no statistical difference between 1- and 2-h air-filter sampling periods as a measure of trapping efficiency. However, the values from the 2-h periods tended to be slightly higher.

When upper, middle, and lower air-filter trap levels were compared in a paired t test for pesticide quantities, there were no statistical differences between levels for any of the pesticides, except DDD, for which the middle air filters were significantly higher than the lower air filters at the 95% confidence level. This appears to be an aberration resulting from low DDD concentrations. An important finding in the operation of the microagroecosystem was that no differences in pesticide concentration at the various air-filter trap levels occurred. This means that with fallow soil and 0.08 m s⁻¹ wind speed, the volatilized pesticide is equally mixed in the air at all levels and no gradients occurred as a result of height above the soil on the air-filter trapping end of the chamber.

Pesticide Volatilization from Fallow Soil—1978. Pesticide volatilization flux, soil moisture, soil and air temperatures, and relative humidity are given for days 0-1 and 9-10 in Figure 1. Equations describing the time course of pesticide flux are given in Table II. The decline of pesticide volatilization rate for days 0 and 3 followed an exponential equation quite well for those pesticides with vapor pressures greater than dieldrin but less well for those with vapor pressures less than dieldrin. However, when the equation was limited to the day 0 values, the rate of vapor decline (-A) for all pesticides was ca. 2. These results demonstrate that under the same conditions all when

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Table II. Highly Significant (99% Confidence Level) Exponential Equations Which Describe Pesticide Volatilization (Flux = $\text{g ha}^{-1} \text{ day}^{-1}$) from Fallow Soil in Microcosm Chambers in 1978

pesticide	vapor pressure, ^a mPa, at 30 °C	day 0	days 8-9	variation accounted for, %
heptachlor	40	$\ln F = 4.8 - 2.55 D^b$	$\ln F = 4.8 - 2.55 D$	87
trifluralin	32.2	$\ln F = 3.9 - 2.61 D$	$\ln F = 3.2 - 2.62 D$	75
lindane	17.04	$\ln F = 3.2 - 2.62 D$	$\ln F = 2.3 - 2.7 D$	85
heptachlor epoxide	2.6	$\ln F = 1.0 - 1.85 D$	$\ln F = 1.5 - 2.4 D$	37
trans-chlordane	1.3	$\ln F = 1.9 - 2.18 D$	$\ln F = 1.3 - 2.7 D$	39
cis-chlordane	1.3	$\ln F = 1.56 - 2.08 D$	$\ln F = 1.9 - 2.3 D$	31
dieldrin	1.3	$\ln F = 1.58 - 1.86 D$		
endrin	0.4 (20 °C)	$\ln F = 1.23 - 1.80 D$		
DDD	0.13	$\ln F = -0.0035 - 1.16 D$		
DDT	0.096	$\ln F = -0.02 - 2.32 D$		

^a Vapor pressure sources were respectively Bowers (1964), Spencer and Clath (1973), Spencer and Clath (1974), estimated. Bowers (1964), Bowers (1974), Spencer and Clath (1974), Gueckel et al. (1973), Ougit et al. (1976), and Ougit et al. (1976). ^b D = days.

pesticides are applied to a soil surface, the decline in volatilization rate for the first several hours after treatment from a fallow soil is similar for many pesticides. The time required for the volatilization rate to decline to half the initial rate was ca. 8 h (6-9 h) for all pesticides. Only the quantity volatilized differs, which depends upon the vapor pressure (Table II) and amounts available (Table I), trifluralin ($49 \text{ g ha}^{-1} \text{ day}^{-1}$), vs. dieldrin ($4.9 \text{ g ha}^{-1} \text{ day}^{-1}$), for example. Spencer and Clath (1974) found the initial rates of trifluralin volatilization were the same for 1, 2, and 10 kg ha^{-1} applications to wet soil surfaces in laboratory studies.

The decrease in volatilization rate for all pesticides on day 0 was rapid until about 1600, when the decrease became less rapid (Figure 1). During the heat of the day the soil surface dried, and then during the night as the soil surface moisture increased, there was a small increase of volatilization relative to early evening hours. Spencer and Clath (1974) in laboratory studies demonstrated that trifluralin volatilization from soil surfaces was about 100 times greater from wet Gila silt loam than from air-dry Gila soil and that water vapor adsorption on dry soil from 50% relative humidity increased trifluralin volatilization also. Similarly, Harper et al. (1976) in field studies showed that volatilization of trifluralin incorporated into a Cecil soil was low when surface soil water content was low during the day and volatilization increased when the surface soil was rewetted from upward soil water movement during the night. The relative nighttime volatilization increase in this study was more pronounced with the lower vapor pressure pesticides (dieldrin, endrin, and DDT) than with the higher vapor pressure pesticides (trifluralin, lindane, and heptachlor). Similarly on day 1, upon sprinkle irrigation and increased day temperature, volatilization increased, but the increase was far more pronounced for the lower vapor pressure pesticides than with the higher vapor, pressure pesticides. Apparently water is more important in desorbing from soil the lower vapor pressure nonionic pesticides than the higher vapor pressure nonionic pesticides.

The volatilization rate continued to decline on day 9 for the higher vapor pressure pesticides, with only a small increase upon moistening the soil and increased soil temperatures. This results primarily from only 4, 7, and 13% of the original applications left (Table III), respectively, for heptachlor, trifluralin, and lindane. Upon irrigation and increased temperature, considerable volatilization occurred for dieldrin, endrin, and DDT on day 9 relative to day 0, and the peak volatilization was greater than for day 1. Presumably the greater day 9 volatilization was because >50% of the applied dieldrin, endrin, and DDT remained (Table III) and because higher air and soil tem-

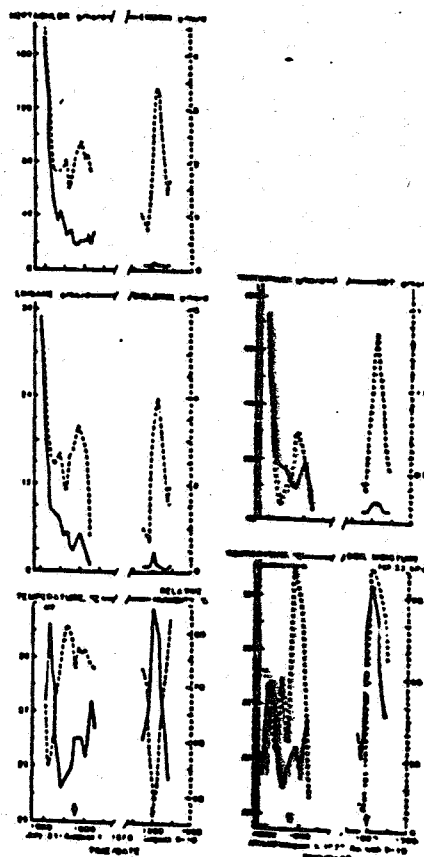


Figure 1. Temperatures, relative humidity, soil moisture, and pesticide volatilization on days 0-1 and 9 in microcosm chambers. Arrows indicate sprinkle irrigation. Solid and dashed curves refer to left and right vertical axes, respectively.

peratures occurred on day 9 than on day 1. Soil surface moisture, because of sprinkle irrigation (Figure 1), was

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Table III. Amount of Pesticide (Percent of Applied Remaining) on Soil Surface in Microagroecosystem Chambers with Time in 1978

pesticide	day									
	0.065 ^a	0.354 ^a	1.41	2.05 ^a	8.98	9.18 ^a	10.96	-k ^b	r ^c	-k ^d
heptachlor	53	62	67	34	5.8	4.2	3.4	0.28	0.99	0.28
trifluralin	72	93	98	51	12	7.3	6.0	0.26	0.98	0.25
lindane	50	75	77	33	17	13	12	0.16	0.95	0.17
heptachlor epoxide	96	112	95	100	65	48	51	0.070	0.95	0.053
trans-chlordane	105	107	99	95	62	55	51	0.058	0.99	0.036
cis-chlordane	110	105	102	106	73	70	60	0.052	0.97	0.036
dieldrin	100	99	95	93	72	72	67	0.036	0.81	0.036
endrin	84	79	78	94	69	72	65	0.021		0.017
p,p'-DDD	83	81	69	80	99	111	186			0.0088
p,p'-DDT	91	91	79	114	126	127	102			0.0072

^a Three replications; all others four. ^b k = slope from exponential equation. ^c Correlation coefficient: 99% = 0.83; 95% = 0.71. ^d Predicted from $\ln k = -3.49 + 0.61 \ln mPa$ ($r = 0.99$) using heptachlor, trifluralin, lindane, and dieldrin.

Table IV. Balance Sheet from 1978 Microagroecosystem Chamber after 11 Days

pesticide	applied, mg	volatilized ^a		soil surface		total, %
		mg	%	mg	%	
heptachlor	315	188 ± 6.6	59.7	11.7 ± 3.52	3.7	63.4
trifluralin	209	125 ± 12.4	60.3	13.6 ± 3.48	6.5	66.8
lindane	65.4	51.2 ± 9.3	78.3	8.51 ± 1.98	13.0	91.3
heptachlor epoxide	6.02	2.56 ± 0.69	42.5	3.35 ± 0.59	55.6	98.1
trans-chlordane	90.3	45.9 ± 7.3	50.8	57.3 ± 9.82	55.7	106
cis-chlordane	75.2	36.9 ± 11.6	49.1	49.2 ± 9.35	65.4	114
dieldrin	150	53.1 ± 14.2	35.4	110 ± 18.6	73.3	109
endrin	150	49.4 ± 12.9	32.9	105 ± 18.1	70.0	103
p,p'-DDD	43.3	20.3 ± 6.1	46.9	52.9 ± 16.6 ^b	122	169
p,p'-DDT	150	15.8 ± 6.6	10.5	167 ± 28.1	111	121

^a Corrected for trapping efficiency. ^b After 9 days.

nearly the same for both days 9 and 1.

The vapor losses of the higher vapor pressure pesticides on day 9 were nearly equal to the lower vapor pressure pesticides (heptachlor ≈ endrin, lindane < dieldrin, and trifluralin > DDT) (note the difference in flux scales, Figure 1). Presumably this would continue a few more days until the remaining higher vapor pressure pesticides (heptachlor, trifluralin, and lindane) on the soil surface approached zero. Heptachlor epoxide, and trans- and cis-chlordane volatilization rates followed similar patterns but were intermediate between the lower and higher vapor pressure pesticides. DDD volatilization followed a pattern similar to DDT.

Six independent variables were measured: relative humidity, subsurface soil, surface soil, and air temperatures, wind speed, and soil moisture. Soil moisture was the most important variable affecting volatilization rate followed by air temperature. Spencer and Clith (1974) observed that soil moisture content above the monomolecular layer greatly influenced vapor density of trifluralin in Gila silt loam soil but not dieldrin (Spencer et al., 1969) and lindane (Spencer and Clith, 1970). Statistically, relative humidity, subsurface and surface soil temperatures, and wind speed had little influence on pesticide volatilization. Most likely their nonsignificance was the result of the air temperature accounting for the soil temperature variations (even though air temperatures are primarily influenced by soil temperatures) and because of the rather narrow ranges of variations, i.e., 40–90% RH, 24–30 °C (subsurface), 23–32 °C (surface), and 0.072–0.086 m s⁻¹ (air movement). Air temperatures ranged from 22 to 33 °C and soil moisture from 9 to 100% of the 33-kPa soil moisture content. Therefore, over short time periods the independent variables needed to describe pesticide volatilization in this study were soil moisture and air temperature.

Pesticide Persistence on Fallow Soil—1978. The amount of pesticide remaining on the fallow soil surface

with time is presented in Table III. The first-order equations gave a good description of the pesticide dissipation rates from soil. The more complicated weather model of Nigg et al. (1977) and the Arrhenius equation of Walker (1974) would not appear necessary to describe pesticide dissipation from moist warm soil under the conditions and short period employed in this experiment.

The higher vapor pressure pesticides dissipated at rapid rates during this experiment whereas the lower vapor pressure pesticides dissipated at either much lower or unmeasurable rates. The apparent increase of DDD and DDT with time possibly resulted from errors in extract dilutions which were not necessary for the more volatile compounds.

If volatilization is the major pathway for dissipation of these pesticides from fallow soil, then one can plot (log-log) the rate of soil dissipation (k) from the first-order equation vs. their respective vapor pressures and predict the persistence of a similar pesticide, provided the vapor pressure is known (Table III). The predicted k values for DDT and DDD were 0.0088 and 0.0072, respectively, which for DDT was not unlike the mean (0.0068) DDT k value reported by Nash (1980a) for persistence of DDT on soil surfaces.

Pesticide Balance Sheet—1978. A balance sheet of the pesticides was constructed for that volatilized plus that remaining on the soil for the 1978 experiment (Table IV). Nearly all of the pesticides could be accounted for, except heptachlor and trifluralin—the two most volatile pesticides. Even though the values for heptachlor and trifluralin were corrected for air-filter trapping efficiency, nearly 35% was missed in some manner. Possibly some heptachlor was lost through photodegradation (Ketchersid et al., 1969), and subsequently we have found that about 25% of heptachlor is transformed (apparently to an alcohol (4,5,6,7,8,8-hexachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-inden-1-ol) according to mass spectra data) during 2 h of aqueous heating. The soils were extracted moist and

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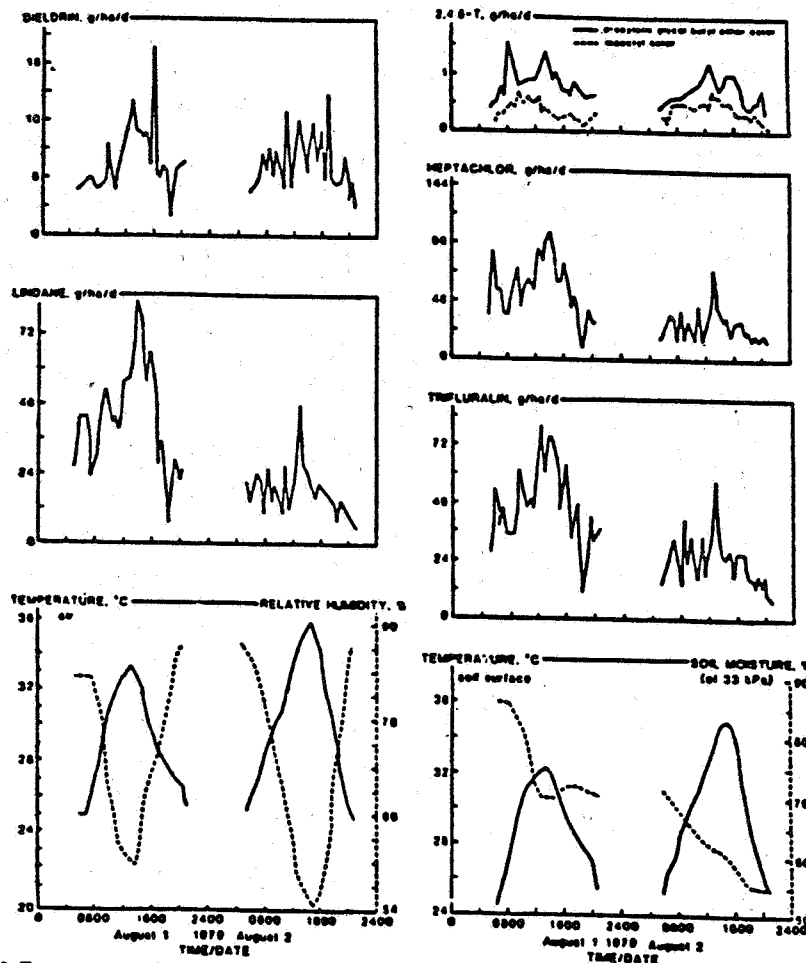


Figure 2. Temperatures, relative humidity, soil moisture, and pesticide volatilization on days 1 and 2 in chambers. Solid and dashed curves refer to left and right vertical axes, respectively, except for 2,4,5-T.

Table V. Highly Significant (99% Confidence Level) Equations Which Describe Pesticide Volatilization (Flux = g ha⁻¹ day⁻¹) from Fallow Soil in Microecosystem Chambers in 1979

pesticide	exponential ^a	stepwise regression ^a	variation accounted for, %
heptachlor	$\ln F = 1 - 0.7 D^b$	$F = 13 - 0.088 RH - 2.7 D$	34
trifluralin	$\ln F = 0.7 - 0.6 D$	$F = -2 + 0.25 SST - 2.13 D$	27
lindane	$\ln F = 0.7 - 0.8 D$	$\ln F = 3.3 - 0.026 RH - 0.81 D$	32
dieldrin		$\ln F = -20 + 3 \ln SST + 1.8 \ln SM$	12
2,4-D PGBEE ^c		$\ln F = -3 - 0.023 RH + 0.03 SM$	17
2,4-D IE ^d		$\ln F = -5.8 + 1.8 \ln \dots - 3.9 \ln D$	13
2,4,5-T PGBEE		$\ln F = -3.3 - 1.5 \ln RH + 1.6 \ln SM$	13
2,4,5-T IE		$\ln F = -21 + 2 \ln SST + 1.6 \ln AT + 1.4 \ln SM$	53

^a Days 1 and 2 after treatment. ^b D = day; RH = relative humidity; SST = subsurface soil temperature; AT = air temperature; SM = soil moisture in percent of 33-kPa moisture tension. ^c Propylene glycol butyl ether ester. ^d Isocetyl ester.

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Table VI. Amount of Pesticide (Percent of Applied Remaining) on Soil Surface in Microcosm Chambers with Time in 1979

pesticide	day								-k ^a	r ^b
	0	0.63	0.81	0.98	1.6	1.8	1.9	2.2		
heptachlor	67	58	49	43	36	39	39	37	0.28	0.93
trifluralin	79	80	64	61	52	59	58	60	0.17	0.81
lindane	76	78	56	50	66	32	18	32	0.53	0.77
dieldrin	100	98	98	97	96	95	95	94	0.027	0.99
2,4-D PGBEE ^c	116	91	70	78	100	59	50	61	0.29	0.75
2,4-D IE ^d	113	79	88	70		75	51	75	0.22	0.73
2,4,5-T PGBEE	131	121	84	95	100	68	62	74	0.30	0.84
2,4,5-T IE	143	105	111	90		115	74	92	0.18	0.63

^a k = slope from exponential equation. ^b Correlation coefficient: 99% = 0.83 and 0.80 and 95% = 0.71 and 0.67 for 7 and 6 df, respectively. ^c Measured as the propylene glycol butyl ether ester. ^d Measured as the isooctyl ester.

water was contained in the extraction solution. On the same soil in the field in 1978, Giotfelty (1981) accounted for 74 and 80% of the initially measured heptachlor and trifluralin, respectively, after 2 days but only 52 and 53%, respectively, of the application.

Pesticide Volatilization from Fallow Soil—1979. In the 1979 experiment, no volatilization data were collected for day 0 in order to more precisely measure the influence of the environmental variables on pesticide volatilization (Table V; Figure 2). Volatilization was measured on days 1 and 2 between 0500 and 2200. Volatilization was influenced more by the diurnal variation of days 1 and 2 than by the first volatilization flush after treatment on day 0, the latter being largely dependent upon time (Table III).

Volatilization of the several pesticides in 1979 followed the same patterns as did the 1978 results for days 0-1 and 9-10 (Figure 2). Heptachlor, trifluralin, and lindane (the higher vapor pressure pesticides) volatilization decreased exponentially from day 1 to day 2, while dieldrin and the phenox herbicide (the lower vapor pressure pesticide) volatilizations were nearly the same on day 2 as day 1.

The propylene glycol butyl ether ester of both 2,4-D and 2,4,5-T (Figure 2) gave the appearance of being more volatile than the isooctyl ester. Presumably, the isooctyl esters hydrolyzed more rapidly, and hence less ester was available for volatilization.

By limiting the influence of initial volatilization, the importance of the several environmental variables was revealed in stepwise regression equations (Table V). In addition to soil moisture, relative humidity and subsurface temperature increased in importance, whereas air temperature decreased in importance. Presumably, the relationships of relative humidity and air temperature were indirect. Rather, it was the increased midday soil temperatures that increased pesticide volatility through their effect on pesticide vapor pressure. Soil moisture steadily declined during the experiment, but higher soil moisture contents at any given time resulted in a higher flux relative to a lower soil moisture content. Although the stepwise regression equations described the data *per se*, those for dieldrin and the phenox herbicides (except the isooctyl ester of 2,4-D) would have little use for modeling purposes because time was of little or no importance, i.e., flux was constant and the amount lost increased linearly with time.

Pesticide Persistence on Fallow Soil—1979. Pesticide persistence on soil was described by the exponential-time equation quite well (Table VI). Stepwise regression analysis of the same data to include the several environmental variables indicated little or no improvement over that provided by the exponential equation in describing persistence of these pesticides on moist fallow soil surfaces. The slopes (k values) from these first-order equations (Table VI) were similar to those obtained from the 1978 experiment (Table III), except for lindane which

was more than triple the 1979 experiment. The k values for 2,4-D and 2,4,5-T were for the esters only; therefore, the k values represent volatilization plus hydrolysis of the esters to their corresponding acids.

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Registry No. trans-Chlordane, 5103-74-2; cis-Chlordane, 5103-71-9; p,p'-DDD, 72-54-8; p,p'-DDT, 50-29-3; dieldrin, 60-57-1; endrin, 72-20-8; heptachlor, 76-44-8; heptachlor epoxide, 1024-57-3; lindane, 58-89-9; trifluralin, 1582-09-8; 2,4-D isooctyl ester, 25168-26-7; 2,4-D propylene glycol butyl ether ester, 1320-18-9; 2,4,5-T isooctyl ester, 25168-18-4; 2,4,5-T propylene glycol butyl ether ester, 62922-39-8.

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